U.S Fish and Wildlife Service

CHANGES IN CONNECTICUT WETLANDS: 1990 to 2010

Cover photos: Pond and grazed meadow created from palustrine forested wetland (top) and beaver modified wetland (bottom) (Ralph Tiner photos)

U.S. Fish and Wildlife Service

Changes in Connecticut Wetlands: 1990 to 2010

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Introduction

The U.S. Fish and Wildlife Service (FWS) recently updated and enhanced its 1980s wetland inventory for Connecticut with 2010 imagery and additional classification (Tiner 2013, Tiner et al. 2013). Since the update required an examination of multiple data sets, the project was also designed to provide an analysis of recent changes in wetlands across the state. The best available digital imagery for such comparison was 1990s imagery. Consequently, an assessment of wetland trends was performed to determine changes in Connecticut's wetlands from 1990 to 2010 and to predict the effect of these changes on wetland functions. This project was funded by the Connecticut Department of Energy and Environmental Protection (CTDEEP). The purpose of this report is to present the findings of this analysis.

Methods

Wetland trend studies involve comparing two or more sets of imagery for a given location to determine how wetlands have changed over time. For this project, we compared wetlands on digital imagery obtained from the state of Connecticut to learn how wetlands changed from 1990 to 2010:

1) 2010 4-band color infrared NAIP digital imagery (August 2010)
(http://www.ctecoapp3.uconn.edu/ArcGIS/Services/images/Ortho_2010_4Band_NAIP/ImageServer)

2) 1990 black and white (panchromatic) imagery (March into May 1990)
(http://www.ctecoapp3.uconn.edu/ArcGIS/Services/images/Ortho_1990/ImageServer).

The 2010 wetlands were previously identified using on-screen image interpretation of the 2010 true color digital imagery (and collateral imagery) in preparing an inventory of current wetlands (Tiner 2013, Tiner et al. 2013). Wetlands were classified following the Cowardin et al. (1979) system and with hydrogeomorphic descriptors following Tiner (2011).

Identifying Changes in Wetlands

Using geographic information system (GIS) technology, the 2010 wetlands geospatial data layer were aligned to leaf-off black and white 1990 digital images. A modification of the Anderson et al. (1979) land use/cover classification system was used to classify the area before wetland creation or after wetland conversion (Table 1). For example, if the area was farmland in 1990 but a pond was present in 2010, the pond represents a gain from agriculture (code 200 in 1990). In 2010, the wetland type would be PUBHx (palustrine unconsolidated bottom permanently flooded, excavated). The 1980s Connecticut wetland inventory data (http://www.fws.gov/wetlands/Data/State-Downloads.html) and USDA soils data (http://soildatamart.nrcs.usda.gov/Survey.aspx?State=CT) were used to help identify and confirm lost wetlands. For example, when a 1980 wetland was not mapped in the 2010 inventory, the area was examined on the 1990 imagery to see if it was still present at that time. If so, the area was considered a 1990 wetland and then the 2010 imagery was re-examined to make sure that the wetland was not there at that time and, if not, to document the current land use or land cover of the area for this wetland loss. Hydric soil mapping units from the soil survey were used in a similar fashion to detect losses. These areas had to show a reliable wetland signature if the area was not mapped as wetland in the 1980s inventory. The target minimum mapping unit for recording trends was generally set at one-quarter (1/4) acre, with smaller conspicuous changes also mapped where possible. For each gain, loss, or major change in type, the location, configuration, acreage, and nature of the change was documented and recorded in the GIS database.

Predicting the Effect of Wetland Changes on Functions

The updated Connecticut wetlands inventory had expanded the classification for all mapped wetlands for use in predicting wetland functions statewide (Tiner et al. 2013). Consequently, all 2010 wetlands had assigned hydrogeomorphic properties – landscape position, landform, water flow path, and waterbody type (LLWW descriptors; Tiner 2011). The trends analysis study identified additional wetland areas that existed in 1990 but were lost by 2010. LLWW descriptors were added to these wetlands. All wetlands that changed in one way or another since 1990 had both a Cowardin et al. classification and an LLWW classification so that an assessment of the change on eleven different functions could be predicted using the landscape-level assessment method employed in the statewide assessment (Tiner 2013b). This procedure therefore permitted an evaluation of the changes on wetland functions, producing, in effect, a cumulative assessment of the recent changes on wetland functions for the entire state.

Data Analysis and Compilation

ArcInfo 10.0 was used to analyze the geospatial data compiled for this project and to produce wetland statistics (acreage summaries) on state wetland trends. Tables were prepared to summarize the results of the inventory (i.e., the extent of wetland losses, gains, and major changes in type). Statistics (acreage summaries) were mostly generated from Microsoft's Access program. Excel spreadsheets were then used to compile the summary statistics and prepare figures for this report.

Table 1. Land use and land cover codes. (Adapted from Anderson et al. 1979)

Code	Category
110	Residential
120	Commercial
130	Industrial
140	Transportation, Communication, & Utilities
141	Roads/Highways
142	Railroads
144	Airports
145	Port Facilities
146	Power Plants
147	Water/Sewage Treatment Plants
150	Mixed Commercial/Industrial
160	Mixed Urban or Built-Up Land
170	Other Urban or Built-Up Land
171	Cemeteries
180	Recreational Land
181	Golf Courses
182	Picnic and Camping Areas
183	Marinas
184	Recreational Parks
185	Stadiums/Racetracks/Zoos
200	Agriculture
211	Cropland
212	Pasture
220	Orchards, Nurseries, Vineyards, Blueberry Farms
225	Sod Farms
230	Confined Feeding Operations
300	Rangeland
310	Herbaceous Rangeland
320	Shrub Rangeland
330	Mixed Rangeland
350	Burned Rangeland
400	Forest
410	Deciduous Forest
420	Evergreen Forest
421	Pine Plantation
430	Mixed Forest
450	Burned Forest
700	Altered or Barren Land
710	Natural Sandy Areas
711	Beaches
712	Dunes and Other Sandy Areas
713	Dry Salt Flats
720	Bare Rock
730	Exposed Substrate due to Mining
731	Stone Quarries
732	Sand/Gravel Pits
733	Strip Mining (active)
734	Abandoned Strip Mines
740	Altered Lands
741	Landfills/Solid Waste Disposal
742	Dredged Disposal Sites
750	Transitional Land (in development)
751	Residential (Single Residence)
752	Residential (Multiple Unit)
753	Commercial
754	Industrial
755	Transportation/Communications/Utilities
756	Industrial/Commercial Parks
757	Unknown

General Scope and Limitations of the Inventory

It is important to recognize the limitations of any wetland mapping effort derived mainly through photointerpretation techniques (see Tiner 2013, 1999, 1990). Wetland data derived from these techniques do not document the location of all wetlands since some wetlands are simply too small to map with the imagery used for this project, while others are too difficult to detect through remote sensing. This is especially true for linear wetlands, drier-end wetlands (i.e., temporarily flooded and seasonally saturated types), and certain evergreen forested wetlands. Also from a trends analysis standpoint, some changes were simply too small to map given the imagery used. While the minimum size of a change for mapping was set at one-quarter acre for this project, smaller conspicuous changes were mapped. Finally, despite our best attempts at quality control, some errors of interpretation and classification are likely to occur due to the sheer number of polygons in the wetland database and the difficulty interpreting subtle changes in wetlands with the source imagery.

The cumulative impact of wetland changes from 1990 to 2010 on wetland functions is a preliminary estimate based on a landscape-level assessment – "Watershed-based Preliminary Assessment of Wetland Functions" (see Tiner et al. 2013 for details). This assessment applies general knowledge of wetlands and their functions to highlight wetlands predicted to perform functions at high or moderate levels.

(Photo: Mike Salter)

Results

Changes in Wetland Acreage

Between 1990 and 2010, Connecticut experienced a net gain of 425 acres in wetlands, due to pond construction across the state (Tables 2 and 3). Despite this gain, the state had a net loss of 273 acres of freshwater vegetated wetlands plus a net loss of about 28 acres of estuarine wetlands. The new ponds are artificial or created wetlands, while marshes, swamps, and bogs are natural wetlands that developed over the past 12,000 years.

Table 2. Status of Connecticut wetlands in 1990 and 2010. <u>*Note*</u>*: The focus of the trends analysis was on vegetated wetlands with persistent vegetation that could be recognized on both leaf-off and leaf-on imagery. The 2010 acreage of individual types may differ slightly from that reported elsewhere due to round-off procedures.*

Wetland Type	**1990 Acreage**	**2010 Acreage**	**Acreage Change**
Estuarine Aquatic Bed	91.7	91.7	-0-
Estuarine Emergent	12,428.2	12,417.2	-11.0
Estuarine Scrub-Shrub	206.9	214.8	+7.9
Estuarine Unconsolidated Shore	4,202.3	4,177.2	-25.1
Estuarine Rocky Shore	80.6	80.6	-0-
Palustrine Aquatic Bed	7,919.6	8,021.2	+101.6
Palustrine Emergent	28,590.6	28,635.7	+45.1
Palustrine Forested	123,701.1	123,430.2	-270.9
Palustrine Scrub-Shrub	26,008.9	25,962.0	-46.9
Palustrine farmed	53.8	53.8	-0-
Palustrine Unconsolidated Bottom	13,991.9	14,053.3	+613.4
Palustrine Unconsolidated Shore	35.2	42.0	+6.8
Lacustrine Unconsolidated Bottom	360.2	360.2	-0-
Lacustrine Unconsolidated Shore	661.4	665.3	+3.9
Lacustrine Aquatic Bed	1,007.8	1,007.8	-0-
Lacustrine Emergent	157.0	157.0	-0-
Riverine Aquatic Bed	133.9	133.9	-0-
Riverine Unconsolidated Shore	52.1	52.1	-0-
Riverine Rocky Shore	1.2	1.2	-0-
State Total	219,132.4	219,557.2	+424.8

Table 3. Changes in Connecticut wetlands from 1990 to 2010. Codes: E2EM – estuarine emergent wetland, E2SS – estuarine scrub-shrub wetland, E2US – estuarine unconsolidated shore, PAB – palustrine aquatic bed, PEM – palustrine emergent wetland, PSS – palustrine scrub-shrub wetland, PFO – palustrine forested wetland, PUB – palustrine unconsolidated bottom, PUS – palustrine unconsolidated shore., and L2US – lacustrine littoral unconsolidated shore. <u>Note</u>: Gains or losses are from or to nonwetlands (dryland or deepwater habitat). Changes in type were often to another wetland in the same ecological system and are also represented as a loss in the original type.

Wetland Type	Gain	Loss	Change in Type*		Net Change
E2EM	--	-9.5	--	-1.5	-11.0
E2SS	+7.9	--	--	--	+7.9
E2US	--	-26.6	+1.5	--	-25.1
PAB**	+54.7	-0.1	+48.1	-1.1	+101.6
PEM	+59.6	-53.6	+134.8	-95.7	+45.1
PFO	+11.7	-112.5	+30.9	-201.0	-270.9
PSS	+16.2	-33.1	+32.5	-62.5	-46.9
PUB**	+606.4	-93.3	+156.7	-56.4	+613.4
PUS**	--	--	+7.6	-0.8	+6.8
L2US	+0.7	-3.8	+7.0	--	+3.9

*A plus sign (+) indicates a gain from another wetland type, while a minus (-) represents a loss to another wetland type.
**These types were considered ponds for this report.

<u>Wetlands Experiencing Net Losses</u>

Net losses were recorded for four wetland types: palustrine forested wetlands (freshwater wooded swamps), palustrine scrub-shrub wetlands (freshwater shrub swamps), estuarine emergent wetlands (salt and brackish marshes), and estuarine unconsolidated shores (beaches and tidal flats) (Tables 2 and 3).

Palustrine Forested Wetlands

Forested wetlands experienced the heaviest losses with roughly 314 acres converted to other wetlands (201 acres) or nonwetland (113 acres). Nearly 200 acres were converted to upland or ponds and 117 acres changed to other wetland types and only 43 acres of gains were recorded (Table 4; Figure 1). Most of the forested wetland loss to upland was attributed to residential development (Figure 2), while the losses to wetlands were largely to emergent wetlands and ponds (Figure 3).

Table 4. Changes in Connecticut palustrine forested wetlands from 1990-2010 and causes. For wetland codes, see Table 3. For land use/land cover codes, see Table 1.

Change	1990	2010	Acreage Change
Loss	PFO	PAB	24.3
	PFO	PEM	101.9
	PFO	PSS	15.3
	PFO	PUB	59.5
	(PFO to Other Wetland)		*(201.0)*
	PFO	110	50.5
	PFO	120	10.5
	PFO	130	7.9
	PFO	141	1.9
	PFO	180	2.2
	PFO	181	2.3
	PFO	211	3.0
	PFO	212	13.8
	PFO	310	2.6
	PFO	320	1.5
	PFO	730	6.0
	PFO	750	9.3
	PFO	751	1.0
	(PFO to Upland)		*(112.5)*
	Loss Total		***-313.5***
Gain	PEM	PFO	16.3
	PUB	PFO	14.6
	(Wetland to PFO)		*(30.9)*
	211	PFO	2.0
	212	PFO	0.6
	320	PFO	1.9
	330	PFO	0.6
	410	PFO	3.4
	430	PFO	0.1
	740	PFO	0.6
	751	PFO	2.5
	(Upland to PFO)		(11.7)
	Gain Total		***+42.6***
Net Change = LOSS			**-270.9**

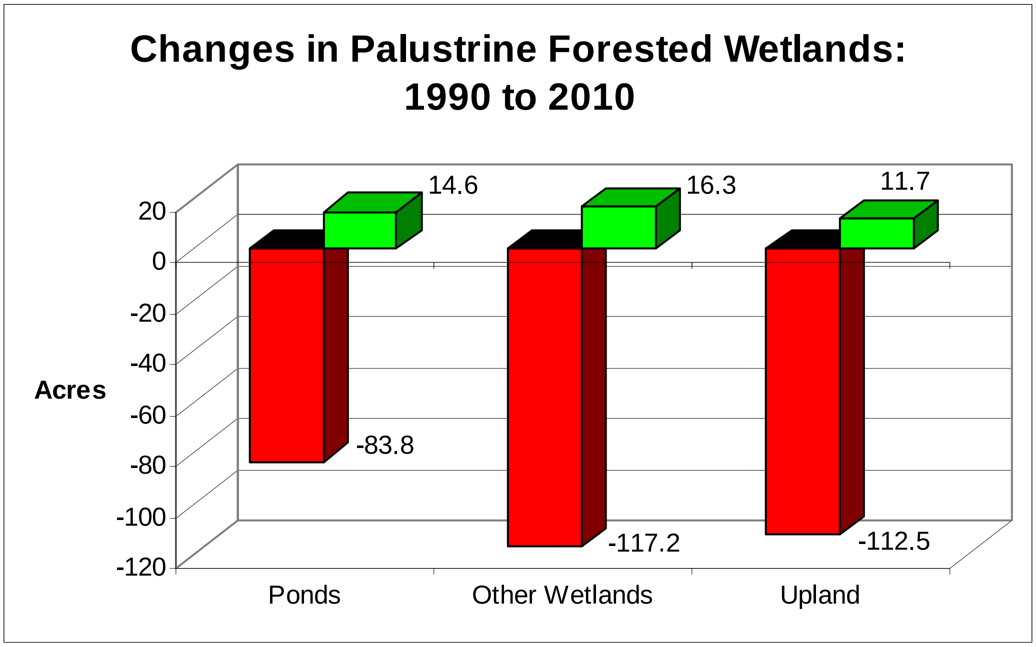


Figure 1. Overall changes in forested wetlands from 1990 to 2010.

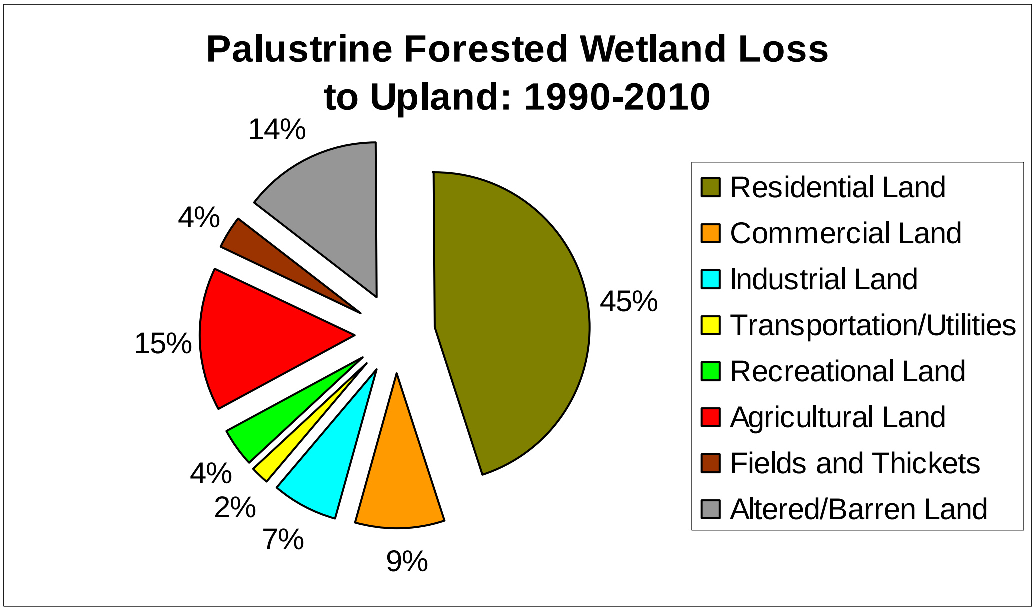


Figure 2. Causes of forested wetland loss to upland from 1990 to 2010. Conversion to fields and thickets may be due to drainage for pastures.

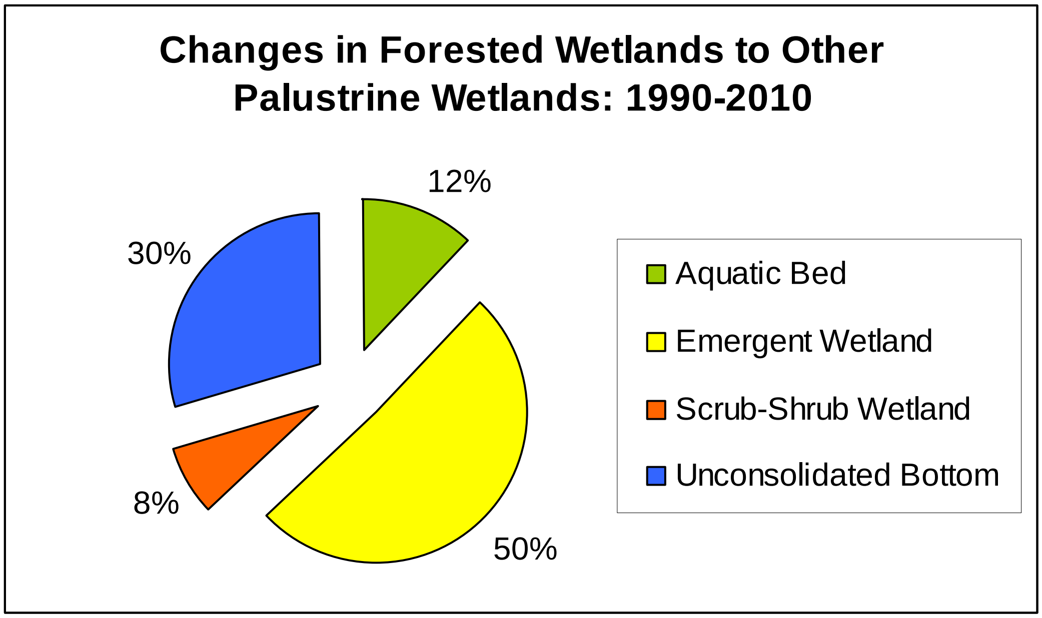


Figure 3. Changes in palustrine forested wetlands to other wetlands from 1990 to 2010. Palustrine aquatic bed and unconsolidated bottom are considered ponds.

Estuarine Wetlands and Palustrine Scrub-Shrub Wetlands

Other wetlands with net losses of wetlands were the two estuarine types (emergent and unconsolidated shore) and palustrine scrub-shrub wetlands (Table 3). The losses of the former two types although small may be the result of sea-level rise which will threaten more of these wetlands in the future (Table 5). Most of the loss of palustrine scrub-shrub wetlands was attributed to pond conversion which created palustrine aquatic beds and unconsolidated bottoms (55.3 acres; Table 6).

Table 5. Changes in Connecticut estuarine wetlands from 1990-2010 and causes. Gains are indicated by + and losses by -. E2SS (estuarine scrub-shrub wetland) increased by 7.9 acres from open water. For wetland codes, see Table 3.

Type	**Change**	**1990**	**2010**	**Acreage Change**
Emergent (E2EM)	Loss	E2EM	E1AB	1.2
		E2EM	E1UB	7.1
		E2EM	E2US	1.5
		E2EM	Airport	1.0
		E2EM	Natural Sandy Area	0.2
	Loss Total			*-11.0*
Net Change = LOSS				**-11.0**
Unconsolidated Shore (E2US)	Loss	E2US	E1UB	26.6
	Loss Total			*-26.6*
	Gain	E2EM	E2US	1.5
	Gain Total			*+1.5*
Net Change = LOSS				**-25.1**

Table 6. Changes in Connecticut palustrine scrub-shrub wetlands from 1990-2010 and causes. For wetland codes, see Table 3. For land use/land cover codes, see Table 1.

Change	1990	2010	Acreage Change
Loss	PSS	PAB	18.3
	PSS	PEM	7.2
	PSS	PUB	37.0
	(PSS to Other Wetland)		*(62.5)*
	PSS	110	2.5
	PSS	120	5.0
	PSS	130	0.4
	PSS	171	0.6
	PSS	182	0.6
	PSS	185	4.0
	PSS	212	11.7
	PSS	230	2.2
	PSS	410	0.3
	PSS	420	0.8
	PSS	730	0.3
	PSS	732	0.5
	PSS	750	3.8
	PSS	753	0.4
	(PSS to Upland)		*(33.1)*
Loss Total			***-95.6***
Gain	PAB	PSS	0.5
	PEM	PSS	14.8
	PFO	PSS	15.3
	PUB	PSS	1.9
	(Wetland to PSS)		*(32.5)*
	130	PSS	0.3
	141	PSS	0.8
	211	PSS	0.8
	212	PSS	1.0
	310	PSS	6.5
	320	PSS	0.7
	410	PSS	0.3
	430	PSS	1.8
	730	PSS	0.7
	740	PSS	1.3
	750	PSS	2.0
	(Upland to PSS)		*(16.2)*
Gain Total			***+48.7***
Net Change = LOSS			**-46.9**

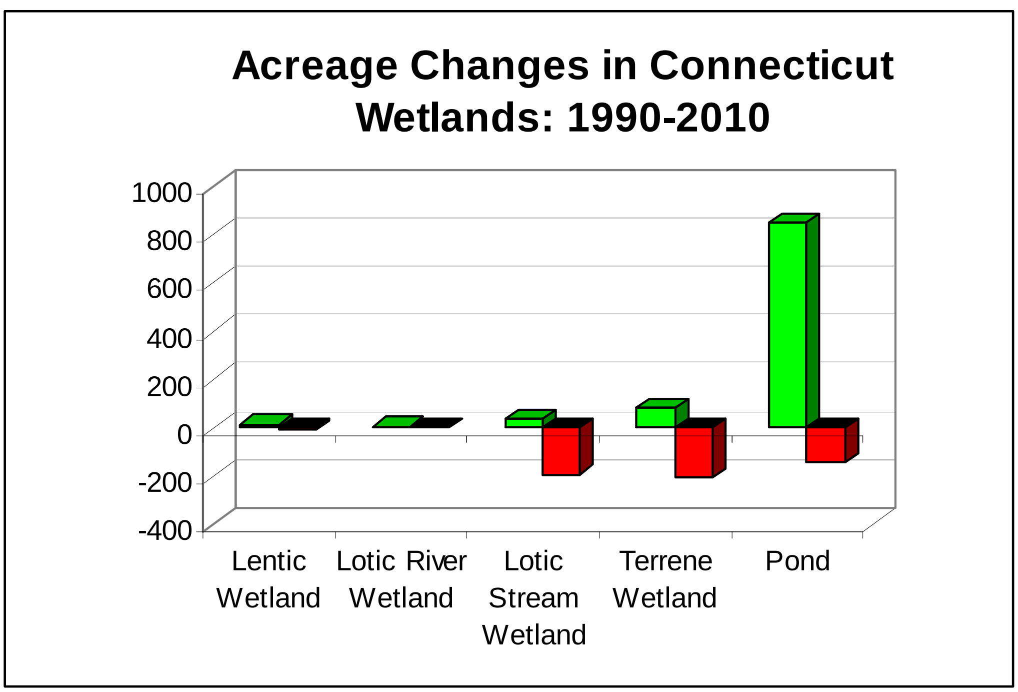
Lotic and Terrene Wetlands

From the landscape position perspective, lotic and terrene wetlands experienced net losses of 150 and 123 acres, respectively (Table 7; Figure 4). Most of the lotic losses were attributed to conversion to ponds (i.e., 130 acres of lotic stream wetlands), while losses to dryland amounted to 59 acres. The opposite was true for terrene losses where most of the losses were due to filling, drainage, or other conversion to dryland (140 acres; mostly isolated basin types), whereas ponds accounted for 64 acres of the losses.

Table 7. Changes in freshwater wetlands classified by landscape position and pond from 1990 to 2010.

Wetland Type	**Gains**	**Losses**	**Net Change**
Lentic	14.9	5.9	+9.0
Lotic River	6.7	5.2	+1.5
Lotic Stream	38.9	190.8	-151.9
Terrene	81.4	204.6	-123.2
Pond	858.3	142.0	+716.3

Figure 4. Changes in Connecticut's wetlands from 1990-2010 by landscape position and pond.



Wetlands Experiencing Net Gains

Three wetland types had significant net increases in acreage from 1990 to 2010: palustrine emergent wetlands (freshwater marshes and wet meadows), palustrine aquatic beds, and palustrine unconsolidated bottoms (the latter two categories are ponds), while less than 8 acres of gain was detected for lacustrine littoral unconsolidated shore and estuarine scrub-shrub wetland (Tables 2 and 3).

Palustrine Emergent Wetlands

Palustrine emergent wetlands experienced a net gain of 45 acres (Figure 5; Table 8). Most of the gain came from forested wetland that is likely to be a temporary change following timber harvest rather than a relatively permanent one, although beaver activity and pond creation with marsh colonization also occurred (Figure 6). In time, forested wetlands are likely to re-establish in many of these areas. Despite the overall net gain, from 1990 to 2010 over 100 acres of emergent wetland were lost mostly by filling for development or pond creation (Table 8). Fifty-four acres of palustrine emergent wetlands were converted to upland, with three activities mainly responsible for this loss: conversion to cropland (agriculture), filling for commercial development, and conversion to fields and thickets (possibly by drainage or abandonment of cropland) (Figure 7).

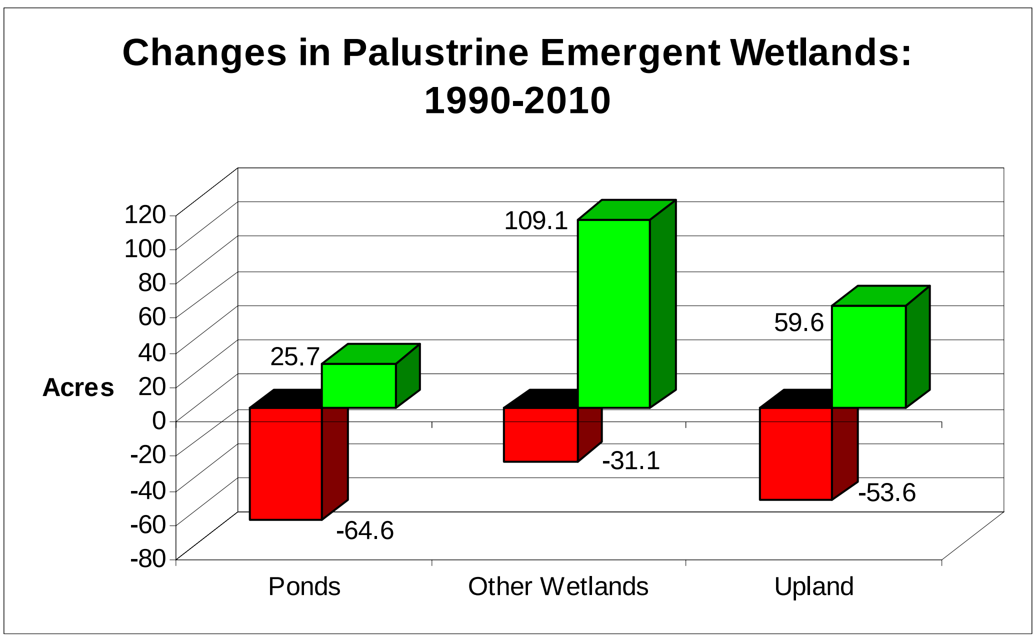


Figure 5. Overall changes in palustrine emergent wetlands from 1990 to 2010.

Table 8. Changes in Connecticut palustrine emergent wetlands from 1990-2010 and causes. For wetland codes, see Table 3. For land use/land cover codes, see Table 1.

Change	1990	2010	Acreage Change
Loss	PEM	PAB	5.2
	PEM	PFO	16.3
	PEM	PSS	14.8
	PEM	PUB	59.4
	(PEM to Other Wetland)		*(95.7)*
	PEM	110	2.5
	PEM	120	14.6
	PEM	130	0.4
	PEM	211	0.6
	PEM	212	20.2
	PEM	230	0.3
	PEM	320	6.3
	PEM	330	4.0
	PEM	732	1.3
	PEM	740	2.6
	PEM	751	0.8
	(PEM to Upland)		*(53.6)*
Loss Total			***-149.3***
Gain	PAB	PEM	0.6
	PFO	PEM	101.9
	PSS	PEM	7.2
	PUB	PEM	25.1
	(Wetland to PEM)		*(134.8)*
	110	PEM	0.2
	120	PEM	0.3
	130	PEM	1.5
	144	PEM	1.1
	181	PEM	0.5
	211	PEM	8.4
	212	PEM	20.2
	320	PEM	1.8
	330	PEM	1.7
	410	PEM	10.4
	420	PEM	2.6
	430	PEM	3.5
	710	PEM	0.1
	730	PEM	0.3
	740	PEM	0.5
	750	PEM	3.3
	751	PEM	0.6
	753	PEM	1.3
	755	PEM	1.3
	(Upland to PEM)		*(59.6)*
Gain Total			***+194.4***
Net Change = GAIN			**+45.1**

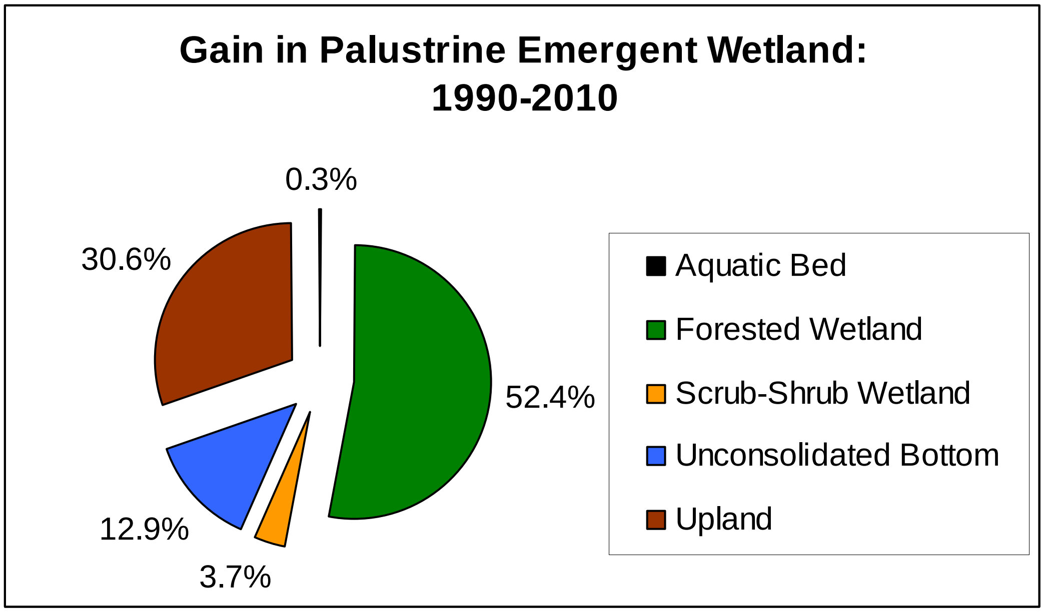


Figure 6. Gain in palustrine emergent wetland from 1990 to 2010.

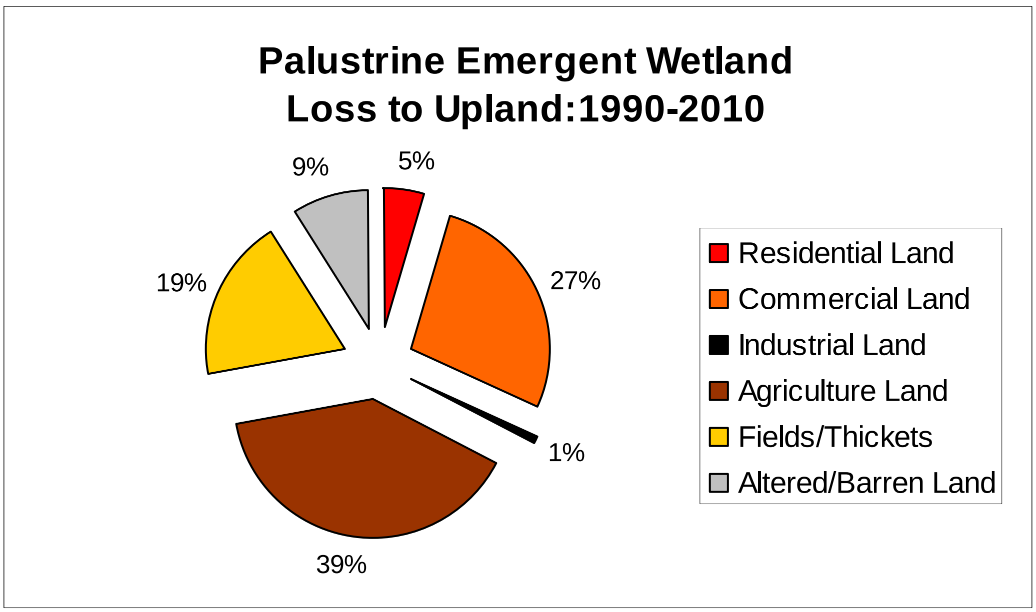


Figure 7. Causes of palustrine emergent wetland loss to upland from 1990 to 2010. Conversion to fields and thickets may be due to drainage for pastures.

Freshwater Ponds and Aquatic Beds

Ponds experienced the greatest gain in acreage, with a net increase of 728 acres (Figure 8; Tables 9 and 10). This is reflected by the combined results for both palustrine aquatic beds and palustrine unconsolidated bottoms. Nearly 865 acres of ponds were created from 1990 to 2010 with 77 percent coming from upland and the rest coming from vegetated wetlands (Figures 9 and 10). During this time, roughly 136 acres of ponds were destroyed or became vegetated wetlands through increased sedimentation or drawdown. Sixty-eight percent of the lost pond acreage was converted to dryland including developments of various kinds (Figure 11). Freshwater aquatic beds alone had a net increase of 102 acres due to pond creation from upland and other wetlands (Table 11).

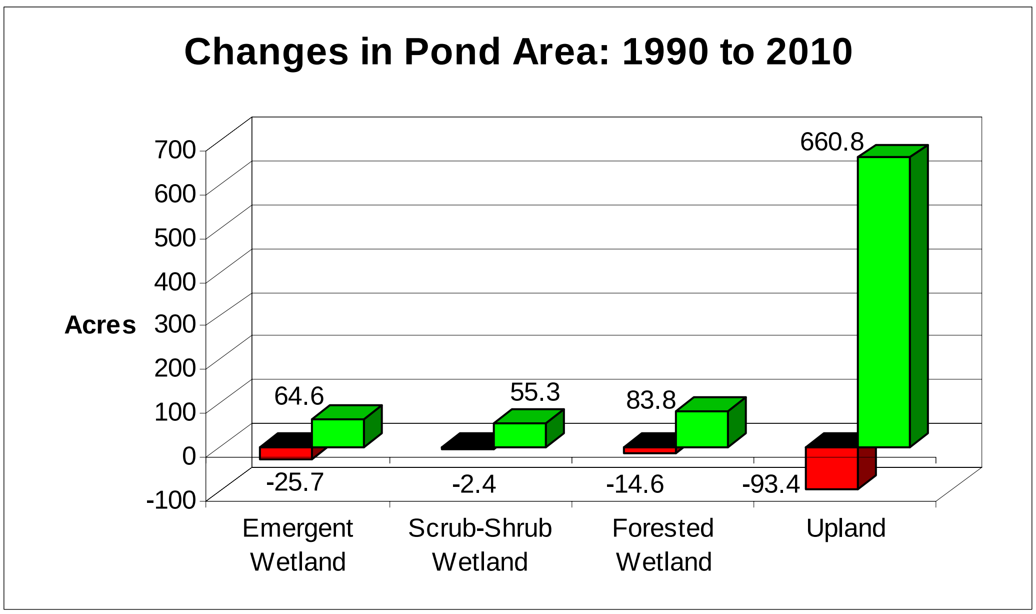


Figure 8. Changes in pond area for Connecticut from 1990 to 2010. For this chart, ponds include PUB, PAB, and PUS types.

Table 9. Gain in Connecticut ponds from 1990-2010 and causes. Ponds in this table include PUB, PAB, and PUS types; changes between these types (e.g., PAB to PUB) are not included since that could be to temporal changes. For wetland codes, see Table 3. For land use/land cover codes, see Table 1.

From Wetland or Land Type	**Acres**	**From Wetland or Land Type**	**Acres**
PEM	64.6	110	13.4
PFO	83.8	120	1.0
PSS	55.3	130	0.9
		141	2.4
Gain from Wetland	***203.7***	144	3.3
		147	0.8
		180	0.3
		181	10.2
		182	0.2
		200	1.0
		211	28.7
		212	136.7
		220	2.6
		230	0.1
		310	31.4
		320	57.1
		330	24.4
		410	67.0
		420	44.1
		421	0.2
		430	99.7
		710	7.4
		730	26.4
		732	23.5
		740	16.8
		741	0.3
		750	28.2
		751	12.0
		753	7.5
		754	4.0
		755	9.0
		756	0.2
		Gain from Upland	***660.8***
		Total Gain	**864.5**

Table 10. Loss of Connecticut ponds from 1990-2010 and causes. Ponds in this table include PUB, PAB, and PUS types; changes between these types (e.g., PAB to PUB) are not included since that could be to temporal changes. For land use/land cover codes, see Table 1.

Type Converted to	**Acres**
PEM	25.7
PFO	14.6
PSS	2.4
Loss to Wetland	***42.7***

Type Converted to	**Acres**
110	8.6
120	7.1
130	11.7
141	2.3
147	1.8
180	0.6
181	0.9
211	0.9
212	2.8
220	0.6
230	0.2
310	5.6
320	6.1
330	2.2
410	2.8
430	2.7
700	5.3
730	3.0
732	12.7
734	5.8
740	1.2
750	4.3
753	3.8
756	0.4
Loss to Upland	***93.4***
Total Loss	**136.1**

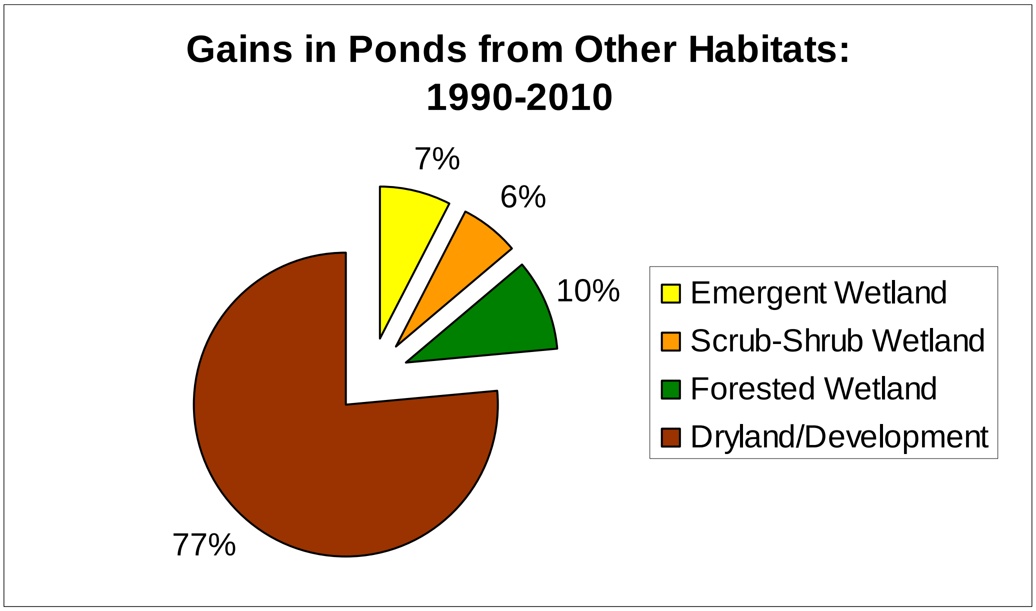


Figure 9. Gains in ponds from other habitats from 1990 to 2010. For this chart, ponds include PUB, PAB, and PUS types.

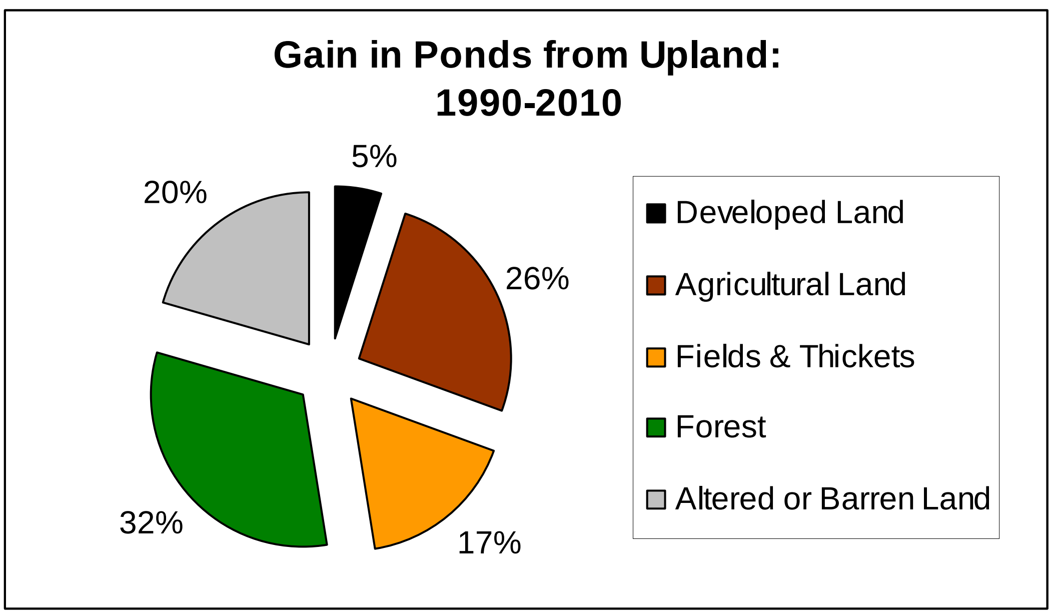


Figure 10. Gains in ponds from upland between 1990 and 2010. For this chart, ponds include PUB, PAB, and PUS types.

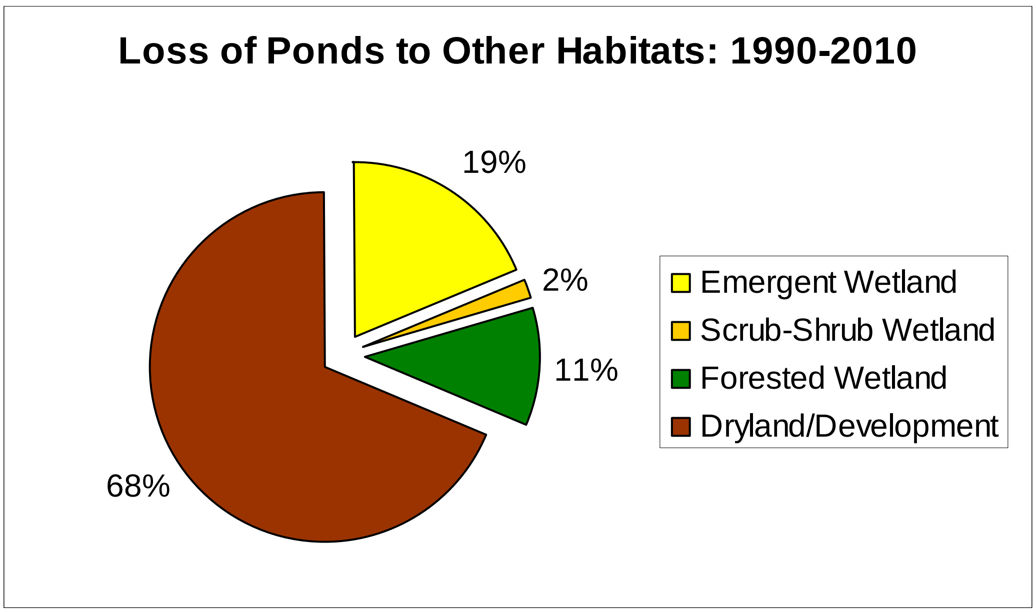


Figure 11. Loss of ponds to other habitats (upland and other wetlands) from 1990 to 2010. For this chart, ponds include PUB, PAB, and PUS types.

Table 11. Changes in Connecticut palustrine aquatic bed wetlands from 1990-2010 and causes. For wetland codes, see Table 3. For land use/land cover codes, see Table 1.

Change	1990	2010	Acreage Change
Loss	PAB	PEM	0.6
	PAB	PUB	0.5
	(PAB to Other Wetland)		*(1.1)*
	PAB	212	0.1
	(PAB to Upland)		*(0.1)*
Loss Total			***-1.2***
Gain	PEM	PAB	5.2
	PFO	PAB	24.3
	PSS	PAB	18.3
	PUB	PAB	0.3
	(Wetland to PAB)		*(48.1)*
	110	PAB	0.5
	181	PAB	0.4
	182	PAB	0.2
	200	PAB	0.9
	211	PAB	2.6
	212	PAB	10.4
	310	PAB	0.3
	320	PAB	4.1
	330	PAB	1.4
	410	PAB	5.3
	420	PAB	0.9
	430	PAB	11.5
	730	PAB	0.3
	732	PAB	6.9
	740	PAB	3.6
	750	PAB	1.2
	751	PAB	0.2
	753	PAB	2.5
	754	PAB	1.3
	755	PAB	0.1
	(Upland to PAB)		*(54.6)*
Gain Total			***+102.7***
Net Change = GAIN			**+101.5**

Significance of Wetland Changes

Despite relatively small changes in the overall area of wetlands since 1990, changes in wetland types can have a substantial impact on wetland functions and the delivery of environmental services as a constructed pond clearly does not have the same functions as a palustrine forested wetland. From 1990 to 2010, Connecticut gained capacity for some wetland functions, while losing capacity for others (Figure 12). The former was due to mainly to an increase in ponds, while the latter was attributed to losses in vegetated types that involved either a change in type (e.g., vegetated wetland to pond) or a conversion of a wetland or portion of a wetland of significance to upland or deepwater habitat.

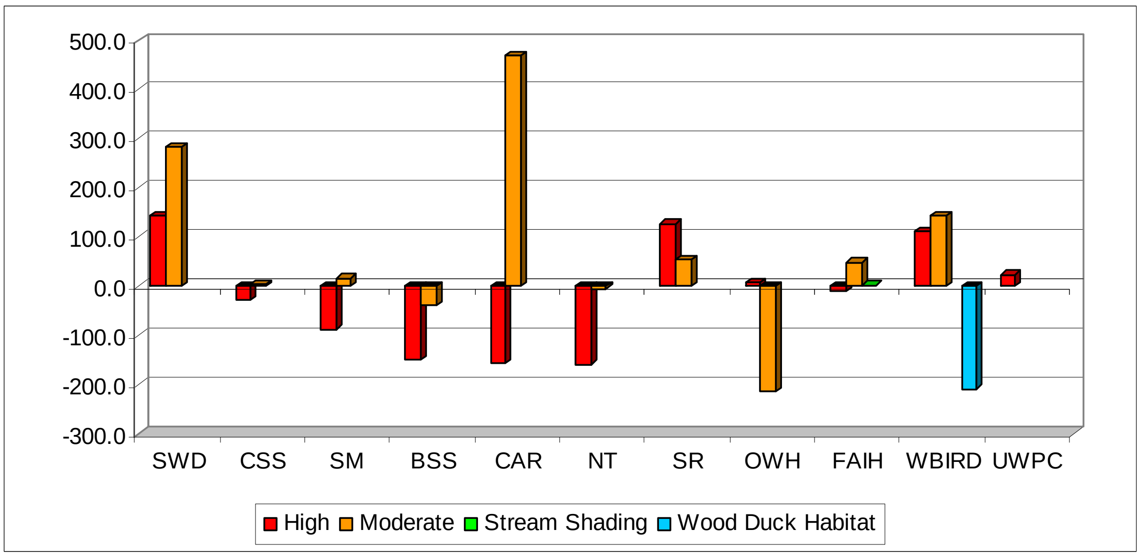


Figure 12. The effect of wetland changes from 1990 to 2010 on wetland acreage providing eleven functions. BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = habitat for unique, uncommon, or highly diverse wetland plant communities. High = predicted high level of performance of a function and Moderate = predicted moderate level of performance.

Functions that increased capacity by more than 100 acres due to a huge gain in pond acreage were surface water detention, carbon sequestration (moderate level), waterfowl and waterbird habitat (excluding wood duck habitat), and sediment/other particulate retention, yet nearly 160 wetland acres that may sequester carbon at high levels of performance and 210 acres of predicted wood duck habitat were lost (Table 12). A modest gain in wetlands predicted to provide fish and aquatic invertebrate habitat at the moderate level was recorded along with 1.3 new acres of wooded wetland that may provide stream shading benefits to these species. A slight gain in unique, uncommon or highly diverse plant communities came from a change in hydrology with seasonally flooded-saturated wetlands (a very common type) becoming semipermanently flooded types which are less common; this change may be a temporary or permanent condition.

Table 12. Net changes in wetland acreage performing each of eleven functions.

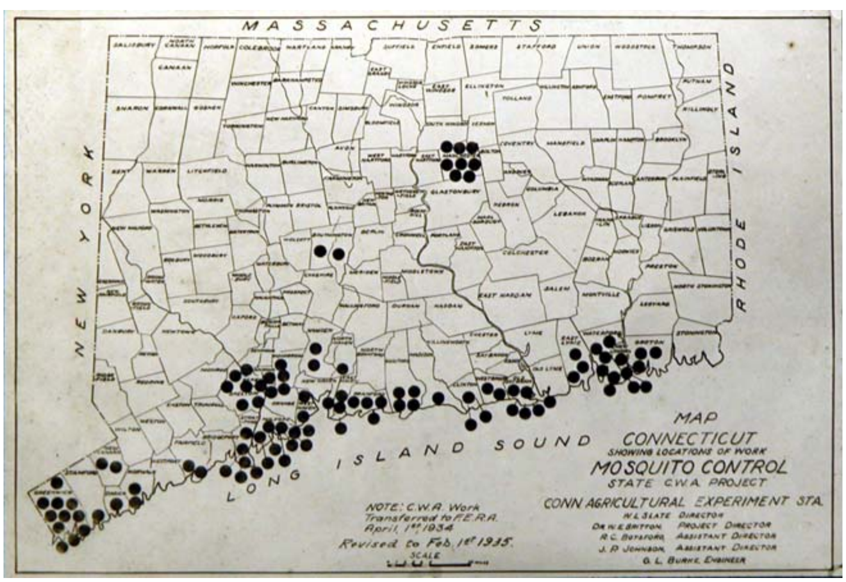
	Net Change in Predicted Performance Level		
Function	**High**	**Moderate**	**Other Significant**
Surface water detention	+142.3	+281.9	
Coastal storm surge detention	-27.7	+2.4	
Streamflow maintenance	-87.9	+16.0	
Bank and shoreline stabilization	-150.2	-40.5	
Carbon sequestration	-157.4	+469.1	
Nutrient transformation	-160.0	-6.1	
Sediment and particulate retention	+127.2	+52.5	
Fish and aquatic invertebrate habitat	-11.8	+47.9	Stream shading +1.3
Waterfowl and waterbird habitat	+110.4	+143.2	Wood duck -210.1
Other wildlife habitat	+8.1	-215.2	
Habitat for rare, uncommon, or highly diverse plant communities	+22.6		

The losses of vegetated wetlands caused reductions in the following functions: coastal storm surge detention, streamflow maintenance, bank and shoreline stabilization, carbon sequestration (high level of performance), nutrient transformation, fish and aquatic invertebrate habitat (high level), wood duck habitat, and habitat for other wildlife (moderate level). A modest shift from high to moderate performance occurred in the streamflow maintenance function caused by conversion of headwater vegetated wetlands to headwater ponds.

Discussion

Based on this study's findings Connecticut experienced relatively small net changes in its wetlands since 1990, with the exception of ponds and forested wetlands. Pond acreage increased by 728 acres, while forested wetlands declined by 271 acres (mostly due to conversion to other wetland types including ponds; 113 acres were lost to development). These results may reflect the effectiveness of federal and state wetland regulatory programs and local ordinances at reducing wetland losses. Prior to these regulatory controls, the state may have lost 33-50 percent of its wetlands by one estimate (Metzler and Tiner 1992) or as much as 74 percent by another (Dahl 1990).[1] For example, by 1900 about half of the tidal marshes between Southport and the Connecticut River were ditched (see Rozsa 1995 for excellent review). Most of the remaining ditch work was done in the 1930s during the Great Depression. At that time, the federal government (Federal Emergency Relief Administration, and later the Civil Works Administration) hired unemployed workers to perform many public works projects. One of these projects involved ditching mostly tidal wetlands to improve drainage as a form of mosquito control. The Connecticut Agricultural Experiment Station identified most of the state's coastal wetlands for these projects (Figure 10). Given significant historic losses, the state's capacity to provide the eleven wetland functions evaluated during this study was already greatly diminished before 1990.

Figure 13. Map showing location of major areas in Connecticut targeted for mosquito control in the 1930s. Extensive ditching of tidal wetlands was initiated at this time. (Courtesy of CTDEEP)



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[1] CTDEEP believed that this figure was misleading and that 40-50% was a more realistic number for freshwater wetlands and up to 65% for coastal wetlands (Metzler and Tiner 1992).

Past studies of wetland trends offer an interesting perspective on what Connecticut's wetlands have experienced more recently. During the last three decades, the U.S. Fish and Wildlife Service conducted two wetland trends studies for parts of Connecticut.[2] One study examined changes in a 780-square mile area of central Connecticut (about 16% of the state) from 1980 to 1985/86 and found a loss of 117 acres of vegetated wetland to nonwetland and 28 acres converted to ponds (Tiner et al. 1989). Although it is not practical to extrapolate these results to the rest of the state, it appears likely that statewide wetland losses were higher during this time than from 1990 to 2010. A more recent study focused on tidal wetlands in southwestern Connecticut and changes from 1974 to 2004 (Tiner et al. 2006). That study found more than 50 acres of salt marsh loss over three decades including 4.59 acres from 1995 to 2004 (Table 13). The present study detected a net loss of 11 salt marsh acres from 1990 to 2010. This is a conservative estimate and if a more comprehensive analysis were performed (i.e., with a smaller targeted minimum area), the loss would be greater, but how much greater is unknown. Given the significance of coastal wetlands, an examination of the threat from rising sea-level warrants more attention.

While it is appealing to compare the 1980s inventory results with the 2010 findings, this would not provide a good comparison since the surveys employed different techniques. For example, the current inventory is more detailed than the prior inventory and contains areas that were not detected as wetland in the earlier survey due to imagery analysis and use of collateral data.

Besides discouraging development in wetlands through regulatory programs, two other factors may be working to further reduce wetland losses. Mitigation projects for permitted wetland losses may account for some of the reduction in the acreage of wetland lost between 1990 and 2010 as these projects seek to replace lost wetland area with newly created or restored wetlands – a gain in wetland elsewhere. Also pro-active restoration projects that are not associated with wetland alteration projects increase wetland acreage or change the type of wetland (e.g., from palustrine emergent to estuarine emergent for some coastal marsh restoration projects).

Recommendations for Further Study

Given widespread concern about the impact of rising sea levels on coastal resources, a monitoring program should be established to examine recent and future changes in tidal wetlands. Studies documenting changes on a decade-to-decade basis like to the one prepared for selected coves in southwestern Connecticut (Tiner et al. 2006) would be extremely beneficial. Each year tidal wetlands in a particular section of the coast could be examined, with full coastwide coverage completed every five years.

[2] The FWS also conducted studies of eelgrass beds in eastern Long Island Sound but they are deepwater habitats rather than wetlands, so those findings are not discussed in this report (see Tiner et al. 2003, 2007, 2010 for details).

Table 13. Acreage changes in selected salt marshes in southwestern Connecticut from 1974 to 2004. (Tiner et al. 2006)

				Acreage					
Salt Marsh System	**Marsh Zone**	**1974**	**1981**	**1986**	**1990**	**1995**	**2000**	**2004**	**Overall Acreage Change (% Change)**
Canfield Island Cove	Tidal Flat	32.15	32.72	34.58	37.58	38.16	39.87	40.51	+8.36 (26.0)
	Low Marsh	27.61	27.08	25.36	22.53	21.90	20.62	20.06	-7.55 (27.3)
	High Marsh	48.13	47.71	47.25	47.07	46.71	46.36	46.42	-1.71 (3.5)
	Open Water	14.95	14.95	14.95	14.87	14.89	14.95	15.17	+0.22 (1.5)
	Aquatic Bed	0.80	0.75	0.78	0.78	0.78	0.81	0.49	-0.31 (38.8)
	Beaches	0.50	0.41	0.45	0.43	0.47	0.47	0.47	-0.03 (6.0)
	Palustrine Tidal	0.00	0.00	0.45	0.53	0.84	0.31	0.31	+0.31 (na)
Cos Cob Harbor	Tidal Flat	17.41	19.33	21.68	22.40	22.27	22.70	22.67	+5.26 (30.2)
	Beach	73.57	73.57	73.57	73.57	73.57	73.57	73.57	0.00 (0.0)
	Rocky Shore	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.00 (0.0)
	Low Marsh	19.38	17.09	14.77	13.88	13.90	13.56	13.58	-5.80 (29.9)
	High Marsh	15.85	16.15	15.94	16.19	16.30	16.25	16.25	+0.40 (2.5)
	Aquatic Bed	16.55	16.61	16.69	16.61	16.61	16.58	16.58	+0.03 (0.0)
Five Mile River	Tidal Flat	5.78	6.79	7.22	8.59	9.54	9.63	9.63	+3.85 (66.6)
	Low Marsh	5.75	5.38	5.33	4.23	2.97	2.93	3.04	-2.71 (47.1)
	High Marsh	6.56	5.92	5.53	5.27	5.53	5.48	5.37	-1.19 (18.1)
Grays Creek	Tidal Flat	18.36	20.15	21.48	23.31	24.17	24.95	25.21	+6.85 (37.3)
	Beach	0.41	0.37	0.31	0.32	0.35	0.35	0.32	-0.09 (22.0)
	Low Marsh	7.57	5.99	6.05	4.94	4.09	3.66	3.52	-4.05 (53.5)
	High Marsh	8.22	8.06	6.73	5.99	5.89	5.52	5.52	-2.70 (32.8)
	Aquatic Bed	0.07	0.07	0.07	0.07	0.13	0.15	0.07	0.00 (0.0)
	Open Water	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.00 (0.0)
Greenwich Cove	Tidal Flat	56.39	58.95	62.84	64.35	66.11	67.50	67.12	+10.73 (19.0)
	Beach	2.92	2.90	3.10	2.84	2.98	2.42	2.91	-0.01 (0.0)
	Low Marsh	19.62	17.09	13.48	12.35	11.04	10.50	10.40	-9.22 (47.0)
	High Marsh	21.30	21.01	20.52	20.40	19.81	19.52	19.52	-1.78 (8.4)
	Open Water	14.79	14.79	14.79	14.79	14.79	14.79	14.79	0.00 (0.0)
	Aquatic Bed	3.41	3.41	3.41	3.41	3.41	3.41	3.41	0.00 (0.0)
Scott Cove	Tidal Flat	71.67	83.48	83.93	88.65	88.23	88.46	88.46	+16.79 (23.4)
	Low Marsh	33.39	21.87	21.76	17.01	17.44	17.22	17.22	-16.17 (48.4)
	High Marsh	16.39	16.09	15.75	15.79	15.72	15.72	15.72	-0.67 (4.1)
	Open Water	3.03	3.03	3.03	3.03	3.03	3.03	3.03	0.00 (0.0)

Summary

Between 1990 and 2010, Connecticut experienced a net loss of 273 acres of freshwater vegetated wetlands plus a net loss of about 28 acres of estuarine wetlands while pond acreage increased by 722 acres. The new ponds are artificial or created wetlands (some built from upland and others from wetlands), while marshes, swamps, and bogs are mostly naturally formed wetlands that developed over the past 12,000 years. These changes have altered the delivery of environmental services (functions) provided by the state's wetland resources. Several wetland functions experienced more than 100-acres of increase in capacity due chiefly to the construction of new ponds: surface water detention, carbon sequestration (moderate level of performance), waterfowl and waterbird habitat (excluding wood duck habitat), and sediment/other particulate retention. Losses of vegetated wetlands caused reductions in many functions: coastal storm surge detention, streamflow maintenance, bank and shoreline stabilization, carbon sequestration (high level), nutrient transformation, wood duck habitat, and habitat for other wildlife (moderate level).

When compared with past studies of wetland trends, we find that the status of Connecticut's wetlands appears to have dramatically improved during the past two decades and with continued vigilance from regulatory programs and more pro-active restoration initiatives, the functions that Connecticut wetlands perform and the values they provide will continue to benefit both people and resident and migratory fish and wildlife for years to come.

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